BULLETIN
OF THE INSTITUTE OF METALS

VOLUME 2 JUNE 1955 PART 22

JOINT METALLURGICAL SOCIETIES' MEETING

MESSAGE FROM H.R.H. THE DUKE OF EDINBURGH, K.G., PATRON

I extend a cordial greeting and warm welcome to all the delegates to the British Section of the international metallurgical conference assembled in London.

This conference is another important example of co-operation between the British Commonwealth and the free peoples of the world in a field of research which has already, during the present century, exerted a profound influence on our material civilization. The extension of knowledge of the physical properties of materials under varying conditions of stress and temperature is the basis of the new industrial revolution now in progress. Man's success in achieving supersonic speeds in flight, high pressure at high temperatures for economic power generation, and the progressive control of atomic energy for industrial service are all dependent on this knowledge.

These applications have clearly demonstrated the limitations of our present knowledge. Therefore I hope that this conference will provide a permanent form of organization that will keep in constant review the progress of metallurgical research in all countries and promote its rapid application for the benefit of mankind.

I wish the conference every success and I am confident that your continued association in work of such importance will foster and maintain understanding and goodwill between the various countries taking part.

Joint Metallurgical Societies' Meeting in Europe

The American Institute of Mining and Metallurgical Engineers and the American Society for Metals have accepted invitations from the Iron and Steel Institute and the Institute of Metals, and from the leading metallurgical societies in Belgium, France, Germany, and Sweden, to hold a Joint Metallurgical Societies' Meeting in Europe. This meeting should undoubtedly rank as one of the most important of its kind ever held, and the members of the European metallurgical societies are keenly looking forward to this opportunity of meeting many Americans engaged in the ferrous and non-ferrous industries or in metallurgical research in national organizations or in the universities.

The meeting will be held from 1 to 7 June in Great Britain, 9 to 12 June in Düsseldorf (Germany), on 13 June at Liège (Belgium), and from 14 to 18 June in France. His Royal Highness, The Duke of Edinburgh, K.G., has graciously consented to be Patron of the meeting in Great Britain.

The objects of this meeting are to establish personal contacts between experts in the U.S.A. and Canada and in Europe, to provide opportunities for scientific and technical discussion, to enable visitors from the U.S.A. and Canada to see something of the metallurgical industries of Europe, and to foster better understanding and co-operation among all concerned.

The scope of the meeting will cover ironmaking (including coke and ore preparation); steelmaking; mechanical working of ferrous and non-ferrous materials; continuous casting; refining and fabrication of non-ferrous metals; heat-treatment; surface treatment (including finishing and coating); metallurgical education and training in industry; and research problems. Most of the technical and scientific work will be conducted by discussion groups. European Group Leaders will guide the discussions.

The technical visits in and near London, the tours to industrial districts in Great Britain, the sections of the meeting in Germany, Belgium, and France, and post-meeting tours to other countries in Europe have been arranged primarily for the members of the American societies. Though it is hoped that there will be accommodation (for ticket holders only) for all who wish to be present at the technical discussions, it is unavoidable that members of the Iron and Steel Institute and the Institute of Metals will not be able to participate in any considerable numbers in the programme of social functions and visits arranged for the American guests and nominated representatives of the European societies.

Copies of the detailed programme of the meeting have been despatched to all members, with a reply form.

WELCOME FROM THE PRESIDENT

It is with the greatest pleasure and cordiality that the Institute of Metals joins with the Iron and Steel Institute in welcoming to this country the American Institute of Mining and Metallurgical Engineers and the American Society for Metals for their European meeting.

Our sincere wish is that during their sojourn here they will have, at their technical sessions, stimulating discussions and helpful interchanges of views and opinions, and that they will moreover find much to interest them in the various works and factories that they are to see, and both pleasure and enjoyment in other places that they will be visiting.

This occasion will provide them, and us, with the opportunity of meeting old friends and making new ones and so foster the spirit of friendship and fellowship which is so valuable an element in gatherings of this kind and in promoting understanding between the peoples of different countries.

I know that all members of the Institute will be very happy to do whatever they can to ensure for our American friends a most successful meeting which will long remain in the memories of those who participate in it.

Maurice Cook

[Baron

H.R.H. The Duke of Edinburgh, K.G.

(Patron (British Section) of the Joint Metallurgical Societies' Meeting)

Technical Sessions

The following subjects have been selected for discussion at the Technical Sessions to be held in London on 2 and 3 June. The names of the Group Leaders are given in parentheses.

I.—Thursday, 2 June, Morning

A. *Blast-furnace practice:* Ore preparation and beneficiation, including agglomerating, sintering, and the use of the resultant materials in the blast-furnace burden. (Mr. G. D. Elliot, Appleby-Frodingham Steel Co.)

B. *Steelmaking:* Basic open-hearth furnace design and operation, with special reference to port design, flow lines, flame radiation, the proper use of instruments, &c. (Mr. W. C. Bell, Stewarts and Lloyds, Ltd.)

C. *Melting and casting techniques in the non-ferrous metals industries,* with particular reference to recent developments in the production of high-quality ingots for subsequent working. (Dr. W. O. Alexander, Imperial Chemical Industries, Ltd., Metals Division.)

D. *Continuous casting,* including the continuous and direct casting of aluminium and aluminium alloy shapes for subsequent working; continuous casting of copper and copper alloys; continuous casting of carbon and alloy steels. (Dr. W. A. Baker, British Non-Ferrous Metals Research Association, and Mr. J. Savage, British Iron and Steel Research Association.)

E. *High-temperature alloys:* Recent developments in their manufacture, use, and properties, including resistance to creep and scaling. (Dr. L. B. Pfeil, The Mond Nickel Co., Ltd.)

F. *Education and training of those engaged in industry.* (Mr. W. D. Pugh, English Steel Corporation, Ltd.)

II.—Thursday, 2 June, Afternoon

G. *Iron and steelmaking:* Desulphurizing and desiliconizing—various methods. (Mr. R. A. Hacking, Richard Thomas and Baldwins, Ltd.)

H. *Steelmaking:* The place of the electric arc furnace in tonnage steel manufacture. (Mr. G. Tinker, Birlec, Ltd.)

I. *Production of steel strip and sheet,* with particular reference to materials suitable for pressing. (Mr. H. Edwards, John Summers and Sons, Ltd.)

J. *Problems of high-speed wire-drawing of ferrous and non-ferrous metals.* (Mr. R. S. Brown, Rylands Bros., Ltd.)

K. *Rate processes in metallurgy:* Nucleation and growth, diffusion, transformation, &c. (Dr. D. McLean, National Physical Laboratory.)

KK. *Practical aspects of the heat-treatment of special alloys,* including equipment and methods of control. (Dr. Ivor Jenkins, Research Laboratories of the General Electric Co., Ltd.)

III.—Friday, 3 June, Morning

L. *Latest developments and future trends in the study of the physical chemistry of steelmaking.* (Dr. J. Pearson, British Iron and Steel Research Association.)

M. *Production of steel ingots of high quality by processes other than continuous casting.* (Mr. N. H. Bacon, Steel Peech and Tozer, Ltd.)

N. *Production of metals of high purity,* including vacuum melting and zone melting and other new techniques. (Dr. J. C. Chaston, Johnson, Matthey and Co., Ltd.)

O. *Extrusion of ferrous and non-ferrous metals,* including the use of lubricants. (Dr. J. W. Jenkin, Tube Investments, Ltd.)

P. *Fracture of metals under static or dynamic loads.* (Dr. N. P. Allen, National Physical Laboratory.)

PP. *Heat-treatment of forgings.* (Dr. H. H. Burton, English Steel Corporation, Ltd.)

American Institute of Mining and Metallurgical Engineers

The American Institute of Mining and Metallurgical Engineers was first organized in 1871, with a membership of 71. Now, with a total membership of over 16,000, it has 39 Local Sections throughout practically the entire United States, and in Canada, Brazil, and the Philippine Islands. Although the Institute has, from its inception, been concerned with both mining and metallurgical activities, the words, "and Metallurgical" were not introduced into its title until 1919.

The first forty years of the Institute's existence were devoted mainly to organization and foundation, but during this time it was already becoming well known in America. It took part in the Centennial Exposition held in Philadelphia in 1876, and in 1893 played a prominent part in the World's Columbian Exposition in Chicago and in the organization of the mining and metallurgical departments of the World Engineering Congress held in conjunction with the Exposition. Another important step was taken in 1904, when the Institute, together with the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, established the United Engineering Society (now known as the United Engineering Trustees). By means of a generous donation from the late Andrew Carnegie, that Society was able to build the Engineering Societies Building at 29 West 39th Street, New York, which has since been the permanent headquarters of the Institute. The three societies, together with the American Society of Chemical Engineers, which joined at a later date, inaugurated the Engineers Joint Council, and each party endows the Engineering Societies Library.

The formation of Professional Divisions of the A.I.M.E. began in 1918, when the American Institute of Metals was absorbed by the A.I.M.E. as the Institute of Metals Division. Today there are ten Divisions, each of which is self-governing under the Board of Directors of the Institute: Coal; Industrial Minerals; Minerals Beneficiation; Mining, Geology, and Geophysics; Extractive Metallurgy; Institute of Metals; Iron and Steel; Petroleum; Mineral Economics; Mineral Industry Education. The first four of these Divisions have been grouped into the Mining Branch, the next three into the Metals Branch, and the Petroleum Division forms the Petroleum Branch; each of these Branches has its own monthly publication, viz.: *Mining Engineering, Journal of Metals,* and *Journal of Petroleum Technology.* The last two Divisions are all-Institute ones.

American Society for Metals

The American Society for Metals, which was established in 1913 in Detroit, is devoted exclusively to all phases of the metal industry, and is the largest group of metallurgical engineers in the world. Its original membership of 12 has now grown to over 22,000, 60% of which is employed in the field of metal fabrication, 25% in plants producing ferrous and non-ferrous metals, and 15% in education and research.

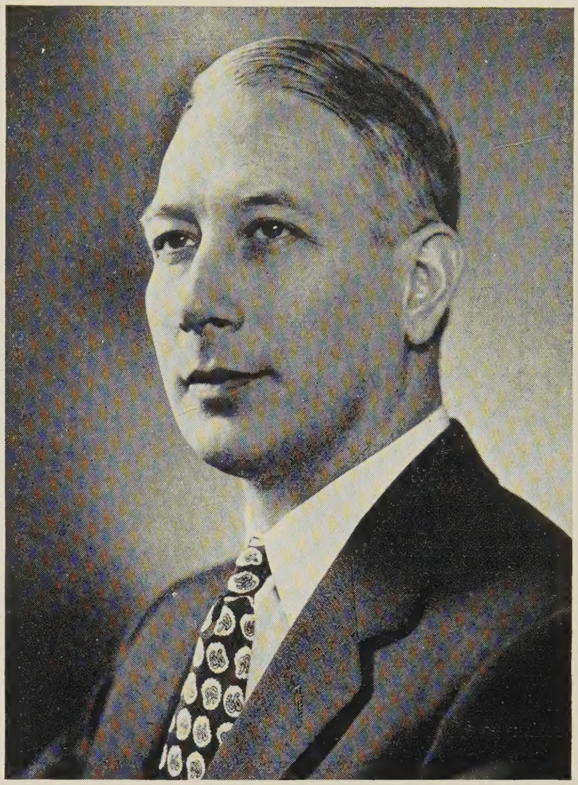
Among the most important of the many functions of the Society is the publication of books and journals for the metals industry. These include the *Metals Handbook,* the monthly *Metal Progress,* the *Metals Review* which is combined with the Review of the Metal Literature, prepared by the Battelle Memorial Institute, and the *Transactions* of the Society. In addition, it also prepares data sheets in booklet form, which are distributed free to the metallurgical departments of colleges and universities, and films pertaining to the metals industry.

OFFICERS OF THE AMERICAN SOCIETIES

[Blackstone Studios Inc.

MR. H. DEWITT SMITH

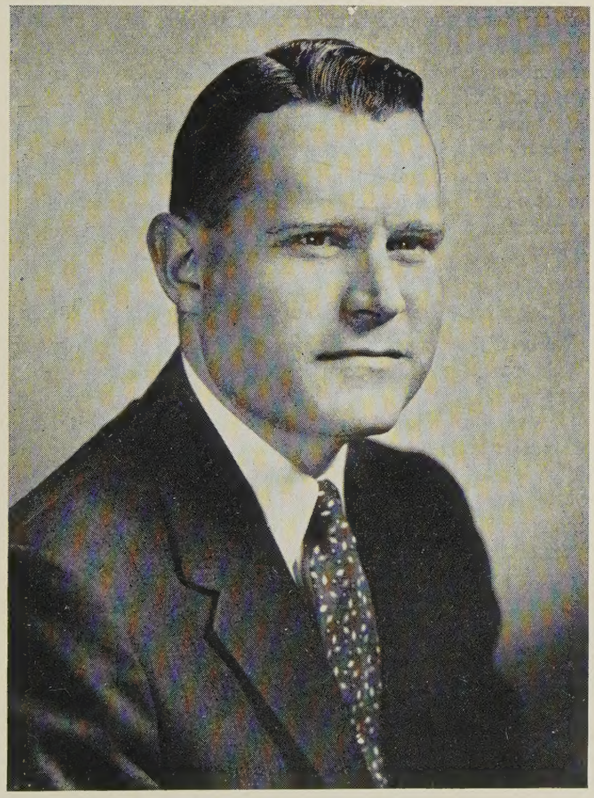
(President, American Institute of Mining and Metallurgical Engineers)



[Fabian Bachrach

DR. E. O. KIRKENDALL

(Secretary, American Institute of Mining and Metallurgical Engineers)



DR. GEORGE A. ROBERTS

(President, American Society for Metals)

MR. W. H. EISENMAN

(Secretary, American Society for Metals)

Another function of the Society is the operation of an employment service for members and for the industry; it has also inaugurated a summer employment bureau available to students, whether members or not, at engineering schools in the U.S.A. and Canada.

The Society is active in the organization and operation of national meetings. It owns and operates the National Metal Exposition, which is held annually, and which incorporates a metallographic exhibit presented by the Society, and the biennial Western Metal Exposition, serving metal engineers in the eleven Western States. The National Metal Congress, and the Western Metal Congress are also sponsored by the Society, which was also the sponsor of the first World Metallurgical Congress held in Detroit in 1951, and attended by delegates from 39 countries.

An active liaison has been established between the Society and the Defence Department of the U.S. Government. The Metallurgical Advisory Board has officially designated the Society as the medium through which information relative to metallurgical problems may be transmitted to the profession.

In the field of education and research, the Society also plays an important part. Through the National Science Teachers' Association, it sponsors the Annual Science Achievement Award, with the aim of creating a student interest in science and the advantages and merits of engineering as a career, and also sponsors awards for science teachers. The Society was also responsible for the inception of the Annual A.S.M. Teaching Award in Metallurgy, which is open to teachers of metallurgy in the U.S.A. and in Canada. Other achievements of the Society include the American Society for Metals Foundation for Education and Research, which has an initial grant of $650,000, and the A.S.M. Visiting Lectureship.

OFFICERS OF THE AMERICAN SOCIETIES

Mr. H. DeWitt Smith

(President, American Institute of Mining and Metallurgical Engineers)

H. DeWitt Smith was born at Plantsville, Conn., in 1888 and graduated E.M. from Yale in 1910. During the next three years he travelled extensively in the Western United States and Mexico as a mining engineer. From 1914 to 1917 he held various positions with the Kennecott (Alaska) Copper Corp., and then went, first as mine superintendent and later as general superintendent, to the United Verde Copper Co., Jerome, Ariz.

In 1924 Mr. Smith went into the Industrial Department of the New York Trust Co., but in 1927 he returned to the United Verde Copper Co. as sales manager. In 1930, he joined the Newmont Mining Corp., with whom he has been connected ever since, except for a break during the last war. From 1941 to 1944 he was executive vice-president of the Metals Reserve Co., a subsidiary of the Reconstruction Finance Corp., in which capacity he was responsible for all domestic metal procurements. He was Vice-President of the Newmont Mining Corp. from 1946 to 1954 and he continues as a member of the Board. In addition he is still actively interested in South African copper mining.

Mr. Smith has been active for many years in the affairs of the A.I.M.E. and was Vice-Chairman of its 75th Anniversary Committee.

Dr. George A. Roberts

(President, American Society for Metals)

George A. Roberts is a graduate of the Carnegie Institute of Technology, where he received the degree of Bachelor of Science in Metallurgy in 1939. He attended the United States Naval Academy from 1935 to 1937 and during the summer of 1938 he was employed by the Bell Telephone Laboratories in New York City.

After graduating, Mr. Roberts was teaching assistant in physical metallurgy and ferrous metallography in the Carnegie Institute of Technology and was granted a Master of Science degree in 1941. He joined the Vanadium-Alloys Steel Company at the company's Latrobe, Pa., plant in 1940. He returned to Carnegie Institute of Technology in 1941–42 as a Vanadium-Alloys Steel Company graduate fellow, and was awarded the degree of Doctor of Science in 1942. He was appointed Research Metallurgist to the Vanadium-Alloys Steel Company in 1942 and is today the Company's Vice-President, Technology.

He is a Past-Chairman of the Pittsburgh Chapter of the A.S.M. (1949–50) and has served as a member of the A.S.M. Publications Committee. He was elected Vice-President of the Society in 1953, after completing a two-year term as A.S.M. National Trustee. He is co-author of " Tool Steels ", published by A.S.M.

Dr. E. O. Kirkendall

(Secretary, American Institute of Mining and Metallurgical Engineers)

Ernest O. Kirkendall was born in East Jordan, Mich., in 1914 and studied at Wayne University and the University of Michigan. He was awarded the Doctor of Science degree in Metallurgical Engineering at the latter University in 1938. From 1937 to 1946 Dr. Kirkendall taught at Wayne University, first as Instructor and later as Assistant Professor of Metallurgical Engineering. Simultaneously he acted as metallurgical consultant to the Progressive Welder Co., Detroit.

In 1946 Dr. Kirkendall was appointed Assistant Secretary of the American Institute of Mining and Metallurgical Engineers and early in the present year became Secretary.

Dr. Kirkendall's research work was concerned mainly with the rates of diffusion of copper and zinc in brass, and his name is associated with the now well-known " Kirkendall effect ".

Mr. W. H. Eisenman

(Executive Secretary, American Society for Metals)

William H. Eisenman, a founder-member of the American Society for Metals, has been its National Secretary for thirty-seven years.

He was born in Jamestown, Ohio, and received his academic technical training at Kenyon College, Stanford University, Morningside College, and Ohio State University. After holding several teaching posts, he became, in 1918, National Secretary of the American Society for Steel Treating (now American Society for Metals).

Mr. Eisenman has directed the National Metal Congress and Exposition, the largest annual industrial exposition held in America, for thirty-seven years, and has also directed the Western Metal Congress and Exposition eve . ince it was first held in 1929.

He has served in many technical and civic organizations, and has been secretary of the Metal Treating Institute, secretary of the Metals Group of the National Research Council, director of Cleveland Convention and Visitors Bureau, &c.

INSTITUTE NEWS

Representation on the Council

Sir CHARLES BRUCE-GARDNER, Bt., has succeeded The Hon. R. G. Lyttelton as representative of The Iron and Steel Institute on the Council.

Corresponding Members

The Council has decided that the term of office of Corresponding Members to the Council should normally be a period of four years, which is the same as that of Ordinary Members of Council. In accordance with that new rule, the following Corresponding Members retired on 30 March 1955, and the President has conveyed to them the Council's warmest thanks for their services to the Institute during their periods of office, which in some cases amount to many years:

Retirements

Belgium	H. P. A. FÉRON
France	Professor P. A. J. CHEVENARD
,,	J. MATTER
India	N. P. GANDHI
Netherlands	M. HAMBURGER
South Africa	Dr. G. H. STANLEY
Spain	Professor J. ORLAND
Sweden	Professor C. A. F. BENEDICKS
,,	Professor A. HULTGREN
U.S.A.	Professor C. S. SMITH

New Appointments

The following Corresponding Members to the Council have been appointed for periods of four years, with effect from 30 March 1955:

Argentina	J. A. SABATO
Australia	C. BLAZEY
Austria	Professor Dr. E. SCHMID
Belgium	Professor R. E. DE. STRYCKER
Brazil	Dr. L. C. CORRÊA DA SILVA
Chile	Professor J. PAÏDASSI
Denmark	Dr. B. LUNN
Finland	Professor H. M. MIEKK-OJA
France	Professor G. CHAUDRON
,,	Dr. J.-F.-G. HÉRENGUEL
Germany	Professor Dr. P. BRENNER
,,	Professor Dr. W. O. KÖSTER
India	G. C. MITTER
,,	Professor D. SWARUP
Italy	Cav. Dott. ALDO DACCÒ
Japan	Professor I. OBINATA
Netherlands	Professor Dr. W. G. BURGERS
Norway	A. B. WINTERBOTTOM
Spain	F. TORRAS SERRATACO
Sweden	Professor Dr. E. G. RUDBERG
U.S.A.	Professor MORRIS COHEN

Education

The Council has appointed Professor J. W. CUTHBERTSON, D.Sc., A.M.I.E.E., F.I.M., and Dr. L. B. PFEIL, O.B.E., A.R.S.M., F.I.M., to represent the Institute on the Education Committee of the Institution of Metallurgists.

Dispatch of the "Journal"

In view of the rising costs of dispatch of the monthly *Journal*, the Council has decided that, for an experimental period, copies shall be sent out tightly rolled in a paper wrapper, as many periodicals are nowadays. A substantial annual saving will be achieved in this way, and it is believed that the *Journal* will be received in better condition than is sometimes the case when it is sent out flat. Should any members find, however, that their copies of the *Journal* often arrive in a damaged state, they should communicate with the Secretary.

Separate Copies of Papers

Members are reminded that it is possible to obtain, by annual subscription, separate copies of all papers published in the *Journal*, price 25*s*. per year, post free. This service is convenient for those members who wish to avoid taking a number of different issues of the *Journal* to meetings at which groups of papers are discussed. New subscriptions can begin with Vol. 84 of the *Journal*, which starts next September.

Election of Members

The following 18 Ordinary Members, 3 Junior Members, and 4 Student Members were elected on 28 April 1955:

As Ordinary Members

BEST, Eric Roland, Surveyor, Lloyd's Register of Shipping, Phoenix Chambers, Colmore Row, Birmingham.

CHIPPS, Richard George, Proprietor, "New Pro" Foundries, Chantrey Close, West Drayton, Middlesex.

DENNIS, William Eric, B.Sc., Ph.D., D.I.C., Metallurgist, Atomic Energy Department, Fraser and Chalmers Engineering Works, Erith, Kent.

DULLENKOPF, Walter Karl, Dr.phil.nat., Laboratoriumsleiter, R. & G. Schmöle Metallwerke, Menden/Sauerland, Germany.

FOX, Alfred Benjamin, Development Engineer, John C. Carlson, Ltd., Newman Street, Ashton-under-Lyne, Lancs.

HARVEY, John Robert Victor, Research Metallurgist, Department of Development and Research, T.I. (Group Services), Ltd., Wheelwright Road, Erdington, Birmingham.

HOWE, John Perry, B.S., Ph.D., Nuclear Engineering and Manufacturing, North American Aviation Inc., P.O. Box 309, Downey, Calif., U.S.A.

JAZWINSKI, Stanislaw Teodor, M.Sc., Dipl.Ing., Director of Research, Central Iron and Steel Company (subsidiary of Barium Steel Corp.), Harrisburg, Pa., U.S.A.

LLEWELLYN, David, Lecturer in Metallurgy, County Technical College, Wednesbury, Staffs.

NEWMAN, Leon Stagg, A.B., B.S., Technical Superintendent, Kaiser Aluminum and Chemical Corp., P.O. Box 6217, Hillyard Station, Mead Works, Spokane 28, Wash., U.S.A.

PEREIRA-PINTO, Francisco F., M.S., Metallurgical Engineer, Caixa Postal 3225, Rio de Janeiro, D.R., Brazil.

RIVKINE, James W., Managing Director, Cora, Ltd., 34 Harman Drive, London, N.W.2.

ROBERTSON, William Walter Samuel, O.B.E., B.Sc.(Eng.), M.I.Mech.E., Managing Director, W. H. A. Robertson and Co., Ltd., Lynton Works, Bedford.

ROSS, Roy Ralf, B.S., Metallurgist, Kaiser Aluminum and Chemical Corp., P.O. Box 7354, Halethorpe 27, Md., U.S.A.

THOMAS, Donald Earl, D.Sc., LSR Metallurgy Section Manager, Westinghouse Atomic Power Division, P.O. Box 1468, Pittsburgh 30, Pa., U.S.A.

TRAGERT, William E., B.S., D.Eng., Research Associate, Metallurgy and Ceramics Research Department, Research Laboratory, General Electric Company, P.O. Box 1088, Schenectady, N.Y., U.S.A.

WATANABE, Seiichiro, Director and Deputy Chief of Steel-Making Department, Japan Special Steel Co., Ltd., 6475 Omori l-chome, Ota-ku, Tokyo, Japan.

WHITTAKER, George Alan, B.Sc., Metallurgist, Rolls Royce, Ltd., Pym's Lane, Crewe.

As Junior Members

BARNES, Hubert Owen, Research Laboratory Assistant, Vickers Armstrongs (Supermarine), Ltd., Hursley Park, Winchester.

CHAPMAN, Gerald, Assistant Metallurgist, Telegraph Construction and Maintenance Co., Ltd., Greenwich, London, S.E.10.

HAMILTON, Collins Franklin, B.S., Metallurgical Engineer, Sandusky Foundry and Machine Company, 615 W. Market Street, Sandusky, Ohio, U.S.A.

As Student Members

BRUNNER, Paul Anthony, Technical Apprentice, The Birmingham Aluminium Castings (1903) Co., Ltd., Dartmouth Road, Smethwick.

JACOBSON, Martin I., B.S., Research Fellow, Department of Metallurgy, Ohio State University, Columbus, Ohio, U.S.A.

SANDS, Raymond Leonard, Sand Technologist, Laboratory, F. H. Lloyd and Co., Ltd., James Bridge, Wednesbury, Staffs.

UPTHEGROVE, William Reid, M.S.E., Research Student, Department of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor, Mich., U.S.A.

PERSONAL NOTES

DR. L. AITCHISON has received a Special Insignia Award in Technology from the City and Guilds of London Institute.

PROFESSOR H. F. ANTELO has been appointed Head of the Technical Section of the Centro de Industriales Siderurgicos, Buenos Aires.

MR. W. V. BINSTEAD has joined the Development Department of the British Welding Research Association.

SIR LAWRENCE BRAGG has been elected a Foreign Member of the Académie des Sciences.

DR. F. E. CARTER has recently retired. He was Director of Physical Research at Baker and Co., Inc., Newark, N.J.

DR. HORACE W. CLARKE, Chairman and Managing Director of James Booth and Co., Ltd., has been elected President of the Aluminium Development Association. He previously held this office 10 years ago, when the Association was first formed. Dr. Clarke has also been elected a Fellow of the Royal Aeronautical Society.

CAV. ALDO DACCÒ, President of the Associazione Italiana di Metallurgia and a Corresponding Member to the Council for Italy, has been awarded an honorary doctorate of Ferrara University, in recognition of the important contributions he has made to metallurgical developments in Italy.

DR. M. J. DAY has been appointed Director of Research and Development, Crucible Steel Corp., Pittsburgh, Pa.

MR. J. H. EVANS has been appointed Chief Metallurgist of the British Timken Organization.

DR. H. K. HARDY, Senior Metallurgist, Fulmer Research Institute, has been awarded the degree of D.Sc.(Eng.) of London University for his work in the field of physical metallurgy. Dr. Hardy's research has been mainly concerned with the mechanism of precipitation, the effect of trace elements on precipitation, and the application of thermodynamics to phase constitution. A number of papers by him on these subjects have appeared in the Institute's *Journal* in recent years.

MR. D. R. HARRIES has left Cambridge University and taken an appointment in the Metallurgy Division, Atomic Energy Research Establishment, Harwell.

MR. J. HESLOP has been awarded the Ph.D. degree of Leeds University.

DR. W. HUME-ROTHERY has been awarded the Losana Gold Medal of the Associazione Italiana di Metallurgia. Dr. Hume-Rothery was recently appointed George Kelley Reader in Metallurgy in the University of Oxford.

MR. N. H. MASON has been appointed Assistant Director, Metallic Materials, Directorate of Materials Research and Development (Air), Ministry of Supply.

MR. R. S. MOORE has been appointed Metallurgist to the Anti-Attrition Metal Co., Ltd., Maidenhead.

MR. J. H. PALM has joined Hilarius' Draadindustrie en Handelmaatschappij N.V., Haarlem.

MR. F. C. PORTER has been appointed Corrosion Metallurgist, Avro Aircraft, Ltd., Toronto, Ont.

MR. E. AUSTYN REYNOLDS has resigned his position as Director of Development with T.I. Aluminium, Ltd.

MR. R. T. ROLFE, who, as recently noted in the *Bulletin*, has retired from the post of Chief Metallurgist to W. H. Allen Sons and Co., Ltd., remains associated with the Company in a consulting capacity.

MR. A. SPIERS has been appointed Metallurgist to Edwin Danks and Co. (Oldbury), Ltd., Oldbury, Birmingham.

MR. B. TAYLOR has left the British Non-Ferrous Metals Research Association and joined The Mond Nickel Co., Ltd., Development and Research Department, Acton.

MR. J. S. TRITTON has retired from partnership in the firm of Rendel, Palmer, and Tritton, but is remaining as a consultant.

MR. C. G. WILLIAMS has been appointed Chief Metallurgist to Baxters, Ltd., Birmingham.

Deaths

The Editor regrets to announce the deaths of:

MR. JAMES DOUGLAS MOORE GRAY of Toronto, Canada, on 24 March 1955. He had been a Member of the Institute since 1927.

MR. KEIZO NISHIMURA, President of Furukawa Electric Co., Ltd., Tokyo, on 18 February 1955.

MR. JAMES PATRICK, Metallurgist, The British Aluminium Co., Ltd., on 16 February 1955. He had been a member of the Institute since 1932.

MR. ROBERT THOMAS PRIESTMAN, Governing Director of T. J. Priestman, Ltd., Birmingham, on 2 May 1955.

OBITUARY

Professor C. O. Bannister

With the passing of Professor C. O. Bannister, the metallurgical world has lost one of the few remaining men who did so much pioneering work, especially in developing the use of the microscope in the investigation of theoretical and practical problems and in developing fundamental research. He was one of a group of men—including Carpenter, Law, Merrett, Smith, Rosenhain, and Stansfield—who were inspired by Roberts-Austen and one or two Continental metallurgists and who assisted largely in the laying down of the foundations of physical metallurgy in Great Britain. Upon these foundations later generations have built the great mass of knowledge on the structure of metals and alloys and on their heat-treatment and mechanical transformation which has so widely contributed to the advance of engineering methods and of the materials employed in them.

Charles Olden Bannister was born in 1876 and educated at Stourbridge Grammar School and at the Royal School of Mines under the late Professor Sir William C. Roberts-Austen (1896–99). He was awarded the Bessemer medal in metallurgy and thereafter remained at the School as Assistant Instructor in Assaying for four years. In 1903 he was awarded a Carnegie Scholarship by the Iron and Steel Institute and in the same year was appointed Head of the Department of Metallurgy of the Sir John Cass Technical Institute (now the Sir John Cass College) and remained there until 1914 when he joined the staff of Messrs. Edward, Riley and Harbord, consulting metallurgists. During the six years of this appointment he applied the technique of microscopy and of the rapidly developing physico-metallurgy to the solution of a variety of problems, difficulties, and failures of everyday engineering life.

In 1920 he was appointed to the Holt Professorship in Metallurgy at Liverpool University. Starting from scratch, he re-established the Department as a worthy school of teaching and research, and the members attending the courses gradually grew until, at his regrettable retirement owing to ill health in 1941, they compared favourably in quality and quantity with those in similar departments elsewhere. It was during this period that he extended the consulting work, which he had begun whilst at the "Cass" and had continued during his period with Messrs. Edward, Riley and Harbord, and he became well known in the Courts as an accurate and reliable expert witness.

Bannister was one of the few remaining Original Members of the Institute of Metals. He contributed papers to its *Journal* and frequently engaged in the discussions. For many years he was a Member of Council of the Institution of Mining and Metallurgy and served a period as Vice-President. For papers presented to the Institution he was, in 1909, in conjunction with W. N. Stanley, awarded the Premium offered by the Consolidated Gold Fields of South Africa Co., Ltd. Three years later he was the recipient of the Gold Medal provided by the same Company. He also contributed papers to the Iron and Steel Institute and other technical societies.

Bannister was a most likeable friend and colleague, possessed of a rare sense of humour. He was a wise and willing counsellor, encouraging, helpful, and at times severely critical, in the best sense, of men and their work. He believed a true result or opinion could be obtained only if the "pros" and "cons" were vigorously argued.

All those who have known him as friend, as teacher, or as expert witness, or have been privileged to be his colleagues, will cherish his memory in a very deep sense.

VERNON HARBORD

Student's Essay

B11 THE SIGNIFICANCE OF MICROHARDNESS TESTING *

By A. P. MIODOWNIK,† Ph.D., B.Sc., L.I.M., STUDENT MEMBER

SYNOPSIS : Deviations and scatter encountered in microhardness testing at low loads are examined, and their causes attributed to mechanical and physical characteristics of the testing instrument, operational factors, and the microstructure of the specimen. It is shown that the microstructure can lead to real deviations, in contrast to the rectifiable errors associated with the instrument and the operator. The significance of structure-sensitive deviations is discussed with respect to methods of reporting hardness figures obtained at low loads, and with respect to the information which can be derived from microhardness measurements. Having established the advantages and limitations of the method, a comprehensive summary is given of recent uses of microhardness testing in the fields of control and research.

Introduction

MICROHARDNESS testing has been commanding increasing attention during the last decade. This somewhat specialized method of testing was originally considered merely as an extension of conventional hardness measurement to small specimens which limited the maximum size of the hardness impression and consequently also the applied load. Typical applications were to be found in the testing of watch parts, electroplated specimens, and foil. Microhardness testing was subsequently introduced into the field of research, where it permitted the study of variations in hardness due to orientation in single crystals and the study of the hardness of individual microconstituents.

It soon became evident that reproducible results could be obtained only under rigorously controlled conditions, and that in many cases discrepancies and scatter might be specifically associated with the small size of the impressions. The majority of such variations could be traced to a combination of mechanical and physical features associated with the instrument, physiological factors associated with the operator, and insufficient appreciation of the effects of heterogeneous microstructures. Because of the large number of possible contributory errors, many investigators considered that even persistent discrepancies and scatter in results must inevitably be due to errors, this attitude being applied particularly to any evidence of variation of hardness with applied load when using a Vickers indenter.

Some investigators were, however, convinced that variations should be expected from the effect of microstructural factors on the deformation process associated with the making of the hardness impression. On this view-point, the precise variations observed could be used to differentiate between microstructural and micro-stress distributions not readily studied by other methods. Acceptance of the reality of deviations from normal hardness values at low loads, besides offering extra scope for investigation and use of microhardness testing, vitally affects all other uses of the method, since it questions the compatibility of the hardness figures obtained by macro- and micro-hardness tests.

This essay is an attempt at a detailed examination of the possible causes and consequences of low-load microhardness phenomena, followed by a review of current uses of the method.

Types of Low-Load Hardness Deviations Encountered in Microhardness Testing

Full independence of the hardness figure from the value of the applied load is a basic characteristic of normal Vickers hardness testing. The use of a pyramidal diamond at very low loads was considered a problem of instrumentation, and the independence of hardness from load was still expected to be effective throughout the whole range of applied loads. This behaviour is embodied in the two equations:

$$H = k \,.\, P/D^2 \text{ and } P = K \,.\, D^2 \quad . \quad . \quad (1)$$

(where H = hardness, P = applied load, D = diameter of impression, and k, K = constants).

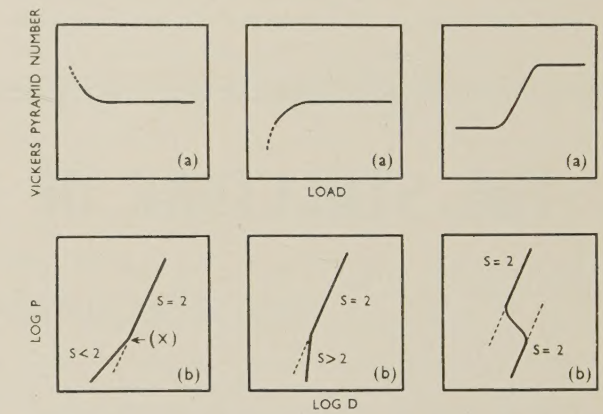


FIG. 1. FIG. 2. FIG. 3.

FIGS. 1–3.—Typical Hardness/Load/Diameter Relationships.

Many different types of variation have been encountered in practice. The hardness may increase with decreasing load (Fig. 1 (*a*)), decrease with decreasing load (Fig. 2 (*a*)), or change from one hardness level to another (Fig. 3 (*a*)). The degree to which such deviations depart from the expected hardness value is frequently followed by plotting the logarithm of the applied load against the logarithm of the diameter of hardness impression, which in the case of a material not exhibiting any deviations (equation (1)) would yield a straight line of slope = 2. Deviations cause a change of slope, each

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type of deviation having a corresponding characteristic log P/log D curve (Figs. 1 (b), 2 (b), 3 (b)). The slope of these logarithmic plots is frequently referred to as the Meyer index, and indicates that the variables are obeying a mathematical relationship of the form:

$$P = k'' . D^n \quad . \quad . \quad . \quad . \quad . \quad (2)$$

rather than

$$P = K . D^2 \quad . \quad . \quad . \quad . \quad . \quad (1)$$

(k'' = constant, n = Meyer index). The value and sign of ($n - 2$) consequently determine the degree and direction of the hardness deviations.

The value of the load at which the Meyer index changes (X in Fig. 1 (b)) determines in what range of applied load hardness variations become apparent, this being frequently in the range 5–300 g.

When a marked scatter in the results is obtained, this may be due to the load being in the vicinity of the change point (X), or to a mixture of phase particles exerting conflicting hardness effects, or to orientation changes. In the latter case, the shape of the impression is frequently affected, and the normal square distorted into kites or diabolos.

If the validity of equation (1) is accepted without question, all the hardness variations mentioned must be attributed to mechanical or operating faults. It will be seen that there are very many possible sources of error, and these must in any case be investigated and rectified, since they would be superimposed on any real variation.

Deviations Attributable to Instrument Construction

Brown and Ineson [1] have made a comprehensive survey of existing microhardness testers. Many studies of likely sources of error have also been made on individual instruments, notably by Taylor,[2] Perryman,[3] Bergsmann,[4] Bückle,[5] Girschig,[6] and Hanemann.[7]

(a) *Errors Associated with the Mechanism of Loading*

Variations in hardness can be easily obtained from inadequate calibration of springs, zero errors, misalignment of load and indenter, and the effect of friction in moving parts.

(b) *Errors Associated with the Indenter*

Imperfections in the tip of the diamond will cause progressive deviations in the hardness figure as the total size of the impression becomes commensurate with that of the imperfection. A " chisel tip " is common, and few diamonds can be produced completely unblemished. If the indenter is not mounted perpendicularly to the surface being indented, the resultant impression will be unsymmetrical.

(c) *Errors Associated with Operation of the Instrument*

While most of the errors discussed so far can be adequately prevented, it is impossible to make an impression without the movement of some part; and two major errors involved with moving parts are impact and vibration. The speed of application of load is probably the source of the majority of deviations attributable to operational factors. A theoretical analysis of impacting made by Girschig,[6] shows that the effective load can be increased by 10% even at quite low loading speeds. Vibration is more amenable to elimination, but can be a potent factor in causing excessively large impressions even if the source of vibration is situated in some other part of the building.[2, 8] Errors have even been attributed to the disturbing effect of convectional currents of air caused by heat from the illuminating system.[9]

(d) *Errors Associated with the Measurement of the Impression*

Since impressions are frequently in the size range 5–50 μ, minute errors in measurement can contribute to appreciable differences in hardness. Amongst the factors involved are the resolving power of the lens system, the type of illumination, diffraction effects associated with the hair-line used for measurement, and varying displacement of the physiological image of the impression with different operators.[10] Attempts have been made to counter resolution effects by using electron microscope replicas,[11] but the variation in results obtained by different operators on the same impression renders an independent check on results most difficult.[1, 4, 10]

Deviations Attributable to the Specimen

(a) *Errors Due to Surface Preparation*

A much better surface finish is necessary in the case of microhardness testing than in the corresponding macrohardness test. Normal methods of surface preparation can, however, lead to other incidental errors. Thus high surface hardness values result from work-hardened layers,[12] and erroneous values can arise from the presence of oxide films.[13] The effects of other factors such as friction,[14] and even surface tension,[15] have to be considered. Electropolished surfaces have frequently been used to demonstrate the effect of progressively removing a work-hardened surface zone,[5, 6, 16] but it is necessary to ensure perfect polishing procedure, as otherwise oxide layers and slight surface waviness contribute to further deviations. The effects of surface preparation are naturally predominant in pure soft metals; when the hardness is appreciable, e.g. above 150 V.P.N., results obtained from mechanically polished and electropolished specimens are very similar.[9, 17, 18]

(b) *Effects Due to the Internal Structure of the Specimen*

Very large variations in hardness can be obtained in a single crystal when the relative orientation of specimen and indenter is altered.[3, 9, 17, 19] Grain-size will affect the hardness figure even in isotropic crystals through the effect of the boundaries. This effect will naturally be greater when considering a duplex structure. The position of boundaries just below the surface of the specimen is usually unknown, and this factor contributes appreciably to scatter in results. It is necessary to interpret with caution any hardness figures derived from impressions in grains where the ratio of the grain-size to the diameter of the impression is relatively small ($\lesssim 3$). The effect of grain boundaries has been admitted by investigators,[2, 3, 5, 6, 8, 9, 17, 20-23] on a theoretical basis, but has not generally been considered as a major cause of observed deviations.

Where boundaries are arranged in regular arrays, as in lamellar aggregates, the crystallography of the formation of such an aggregate (e.g. eutectoid) can cause a dependence of hardness on orientation.[17]

Internal stresses must be considered as a possible factor affecting the size of a microhardness impression, since they affect the extent of plastic deformation. The testing of heterogeneous specimens must lead to a large scatter in results, especially if the specimen has been cold worked [2] or is prone to surface deformation.[1]

The elastic properties of metals are normally neglected in macrohardness measurement, but with the smaller impressions

obtained with microhardness testing, elastic after-effects may be appreciable.[24, 25]

It is obvious that many factors can lead to hardness deviations. Nevertheless, it is also obvious that these factors can be divided into those associated with the structure of the specimen, and those which can be attributed to preparation, instrumentation, and operation. The latter can be adequately controlled, but the former are intrinsic to the specimen. Since the majority of alloys cannot be considered as large-grained, isotropic, single-phase materials, structural effects on microhardness should be expected in most cases. The magnitude of the effect and the precise range of applied loads involved will be determined by the properties of the particular phase aggregate concerned.

(c) *Deviations Encountered in Single-Phase Materials*

It is understandable that grain boundaries of any sort impede plastic deformation, and therefore affect hardness impressions when these are commensurate with the grain-boundary structure. It is more difficult to establish a valid cause for low-load deviations in single-phase materials of large grain-size, but considerable evidence [1, 17, 20, 26–29] is available to show that such deviations can be demonstrated. Now deviations in duplex alloys are acceptable because a change in the resistance to deformation as the load decreases can be demonstrated. The load/hardness relationship of equation (1) can operate only if constant deformation characteristics are assumed, and not solely on account of the geometry of the indenter.[30] On reflection, it can hardly be said that deformation in single-phase materials is uniform. Even if a material is chosen which has lost an appreciable portion of its work-hardening capacity,[30] it can be demonstrated that further work-hardening occurs while the impression is formed.[31] If this is the case for macrohardness impressions, then much greater variations in deformation characteristics must exist during microhardness testing. Dislocation mechanisms for work-hardening are invariably non-uniform, it being possible to have both a high resistance to deformation in the initial stages [32] and a low resistance to deformation in the initial stages.[33] Furthermore, the distribution of strain in the vicinity of wedge indentations is very complex,[34] and the impressed stress varies during the formation of the impression.[17] Low-load hardness deviations in single-phase materials can therefore be attributed to the same basic cause as for duplex alloys, namely that the resistance to deformation is not uniform during the creation of the impression. The structural causes of this non-uniformity are simply on a finer scale. The nature of the variations can be expected to change with small differences in sub-structure, and this has been demonstrated for aged alloys.[5, 35]

General Implications of Low-Load Hardness Deviations

Once it is accepted that real deviations can occur at low loads, care has to be exercised in the expression of the results obtained. Hardness at low loads is obviously inadequately represented by a single figure, unless it is known that deviations occur only at loads below those used. Onitsch [36] has used the procedure of giving the microhardness (MH) at a given diameter (10 μ) together with the logarithmic index:

e.g. $$^{1\cdot 76}\mathrm{MH}_{(10\,\mu)} = 175 \text{ kg./mm.}^2$$

Schultz and Hanemann [7] considered that the microhardness should be given for a limited number of standard diameters, e.g. for 5, 10, and 20 μ. No indication can be obtained by either method as to the value of the critical point (X) in Fig. 1 (b), which decides whether the microhardness will be commensurable with the macrohardness. Another objection to these methods is that emphasis is laid on a constant size of impression; in the majority of cases it is only possible to accurately adjust the applied load.

Bückle [37] has suggested that hardness testing should be divided into three groups: microhardness with loads 1–200 g. (commonly 5–10 g.), low-load hardness with loads 200 g.–10 kg. (commonly 200 g.–2 kg.), and macrohardness with loads greater than 10 kg. Division between microhardness and low-load hardness is made on the basis of the cause of the deviations encountered; namely that in low-load hardness testing reliable results should be obtained, and deviations are due to errors in instrumentation or operation, while in microhardness testing the deviations encountered are real and due to the structure. If the load ranges are adjusted to individual cases, this division could be employed to indicate whether the applied load was above or below the critical point (X) (Fig. 1 (b)). Different symbols such as H_l and H_m could be used for low-load and microhardness, respectively.

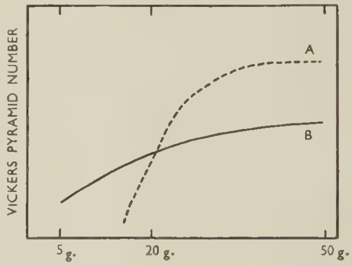

Fig. 4.—The Effect of Low Load Deviations on the Relative Hardness of Two Phases.

Franssen [23] has suggested that macrohardness and microhardness should not be differentiated on the basis of the magnitude of the applied load, but that these terms should refer to the resistance to plastic deformation of an aggregate of phases and a single crystal of an individual phase, respectively. This would be an admirable division were it not for observed deviations in single crystals, and also for the inevitable region of overlap. It is all too often the case that phase particles are too small to accommodate the lightest load, or alternatively so large that a macro-indentation does not cover a representative cross-section of the structure.

Microhardness measurements can, of course, be used to detect changes on a qualitative basis, in which case the complications associated with a change of Meyer index do not arise. It is necessary to realize, however, that in these cases the hardness figures quoted are specific to the applied load used, and may not be commensurate with the macrohardness. Also, the sensitivity of the method in detecting a difference between two phases is affected. Fig. 4 indicates the deviations characteristic of two phases A and B, and it can be seen that at a load of 5 g. there is an appreciable hardness difference between A and B; at 20 g. the two phases have apparently the same hardness, while at 50 g. the relative hardness of the two phases is reversed.

Applications of Microhardness Testing

The main applications of microhardness testing can be divided into two groups. A distinction can be made by considering whether the method is used for control purposes and has as its main object the production of a hardness figure

commensurate with macrohardness, or whether the method is used as a research tool to follow structural changes. Deviations from macrohardness figures are obviously detrimental in the first group, but may give additional information in the second group.

(a) *The Use of Microhardness Testing as a Method of Control*

Very many instances of this type of use for microhardness testing arise in the watch-making industry.[38] The checking of adequate heat-treatment on small pinions, wheels and springs is greatly facilitated, and few alternative methods of control suggest themselves. Other uses involve the testing of razor blades, wire, electrodeposited layers, and foil. Microhardness testing can also be used to great advantage in checking penetration and gradients in surface-hardened specimens, and any similar surface effects such as decarburization. It can also be used to explore the hardness distribution in small soldered, brazed, or welded joints. It should be repeated that all these uses are meant to be extensions of the use of macrohardness measurements, and care should be taken that the applied loads used are above the range where deviations exist, otherwise serious misinterpretation of results may occur.

(b) *The Use of Microhardness Testing in Research*

Microhardness can be used to follow diffusion processes, and if suitable calibration is made it is possible to calculate the diffusion coefficient.[39] Similarly it is possible to detect longitudinal and transverse segregation in small specimens [21] and micro-segregation in the form of coring.[22] Microhardness has been widely used in the study of age-hardening processes. Guy, Barrett, and Mehl [40] used the technique to show that ageing processes proceeded more rapidly at the grain boundaries than in the centre of the grains in copper–beryllium alloys, and a similar effect has been noted by Mishima [41] on aluminium–silver alloys. Berghézan [42] used microhardness measurements to show that ageing was retarded in grains showing evidence of polygonization (aluminium–copper and aluminium–zinc alloys).

Another field in which microhardness has been used extensively is in time/temperature/transformation studies. Bose and Hawkes [43] and Fillnow and Mack [44] both used the method on account of the small size of their isothermal specimens, but obtained an overall hardness figure which showed quite an appreciable scatter owing to the mixture of phases present. On the other hand, Haynes [45] used microhardness measurements to investigate the effect of interlamellar spacing in the eutectoid component on hardness, in structures also showing appreciable quantities of α and β phases. The latter use is much more informative, and permits an estimate to be made of the contribution to overall hardness made by various structural constituents. Similar studies as to the effect of various constituents can, of course, be made on equilibrium structures. Onitsch-Modl [27] has investigated some of the typical phases existing in ferrous alloys, and Saulnier [20] has examined the phases existing in some aluminium-base alloys.

Existing evidence of the effect of a deformed matrix on microhardness is scanty, but indicates some unusual and unexpected effects. Hikage [46] has demonstrated that in the range of small extensions the microhardness decreased after an initial small increase, and Onitsch-Modl [27] has obtained similar results where very little, if any, increase in microhardness occurs for appreciably strained and " work-hardened " specimens.

All these uses differ from those in Group (*a*) by the fact that in the majority of cases it is a change in the hardness which is significant, and the absolute value of little importance. In most of these uses it is adequate to utilize a constant applied load. However, it has been mentioned previously that the deviations obtained at low loads might be profitably used to study structural changes, and several such experiments have also been made. Significant changes in the Meyer index have been obtained for variously aged aluminium–copper [5] and aluminium–manganese [35] alloys. Some of these changes occur without a corresponding microscopical change and have been used by Bückle [35] to estimate the degree of supersaturation obtained on quenching. A similar study on temper-embrittlement [26] indicates characteristic low-load deviations for embrittled and ductile states. A study by Bush and Siebert on temper-embrittlement showed that the Meyer index could be used as a qualitative indication of temper-embrittlement, but reserved judgement on any quantitative significance.[47]

Both Saulnier [20] and Onitsch-Modl [27] obtained varying Meyer indices for different intermetallic phases, but no correlation could be obtained with the type of crystal structure. Saulnier [20] has indicated that small amounts of solute can appreciably affect the Meyer index of the terminal aluminium solid solution.

Conclusion

The increasing use of microhardness testing as a method of control and in research seems more than justified by the information which this test can produce. Microhardness appears to be dependent on the applied load, and significant results can be obtained only by making several impressions at varying loads, and by very careful operation of the instrument. Since microhardness is structure-sensitive, it cannot be used with the same ease as macrohardness; it is, however, capable of giving much more information about the structure of metals.

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LETTERS TO THE EDITOR

Colour Coding of Alloys

SIR,

Many attempts have been made to devise a colour coding for metals, and quite large tables of colour marks have resulted, which have always been very difficult to memorize. Even more disturbing is the number of such codings in different manufacturing and fabricating plants which use identical colour markings though for different materials. It appears that an acceptable colour scheme, which can be standardized, will be obtained only after a uniform way of simple composition coding has been established.

Two attempts in this field have been made, and while the S.A.E. coding for steels has stood the test for more than a quarter of a century, the A.S.T.M. system for non-ferrous metals has recently been rejected by the major manufacturers of wrought aluminium alloys, apparently because it necessitated the use of more than four letters and digits in too many cases. It seems therefore that a code determining the chemical nature of industrial alloys is desirable, but that the number of digits should be limited to four even in designating alloys with many components. This is possible for many alloys of the most widely used base metals if the following system is employed.

The first figure of the code indicates the main alloying addition. The second figure gives the average amount of the main alloying element, if necessary multiplied by a simple fraction. If an element which determines the nature of the alloy is present in amounts up to 0·5%, its amount is indicated by "0". If such an element is absent in the alloy of the group and the absence of this element is significant, a dash may be substituted for zero. Depending on the nature of the alloy, third and fourth digits may be used to show the amounts of two minor alloying elements.

The following examples illustrate the principle for aluminium- and copper-base alloys.

Code for Aluminium Alloys

(1) Main Alloying Element	(2) Amount of Main Element	(3) Amount of:	(4) Amount of:
Cu (= 1)	—	Mg	Si
Ni (= 2)	—	Cu	Mg
Mg (= 3)	—	Si	Mn
Mn (= 4)	—	—	—
Zn (= 5)	—	Mg	Cu

Examples:

Specification or Commercial Designation	Composition Used for Coding	Code No.
14S	Cu = 4·45%; Mg = 0·5%; Si = 0·85%	1401
17S	Cu = 4%; Mg = 0·5%; Si not closely specified	140–
24S	Cu = 4·3%; Mg = 1·6%; Si not closely specified	142–
25S	Cu = 4·45%; Mg < 0·05%; Si = 0·85%	14–1
B.S. 1475 : HG14	Cu = 4·3%; Mg = 0·8%; Si not used	141–
L64 or L65	Cu = 4·3%; Mg = 0·7%; Si = 0·75%	1411
B.S. 1475 : HG15	Cu = 4·15%; Mg < 0·6%; Si < 1·5%	1401
7S, L57	Cu = 2·5%; Mg = 0·35%; Si not closely specified	120–
D.T.D. 443	Cu = 1·5%; Mg = 0·82%; Si = 1%	1211
L40	Ni < 2·0%; Cu = 2·75%; Mg = 0·9%	2131
D.T.D. 246	Ni = 1%; Cu = 2%; Mg = 0·9%	2121
D.T.D. 724	Ni = 1·1%; Cu = 2·25%; Mg = 1·5%	2122
L42	Ni = 1%; Cu = 2·15%; Mg = 1·5%	2122
D.T.D. 130A	Ni = 1%; Cu = 2·15%; Mg = 0·9%	2121
18S	Ni = 2%; Cu = 4·0%; Mg = 0·68%	2241
L25	Ni = 2%; Cu = 4%; Mg = 1·45%	2242
75S	Zn = 5·6%; Mg = 2·5%; Cu = 1·1%	5631
D.T.D. 683	Zn = 5·5%; Mg = 2·75%; Cu < 1·5%	5631
78S	Zn = 6·8%; Mg = 2·75%; Cu = 1·5%	5732
D.T.D. 363	Zn = 6·25%; Mg < 4%; Cu < 3%	5632

Code for Copper Alloys

(1) Main Alloying Element	(2) Amount of Main Element	(3) Amount of:	(4) Amount of:
Al (= 1)	—	Fe	Ni
Sn (= 2)	—	Zn	Pb
Zn (= 3)	0·2 of Zn	Pb	Sn
Ni (= 4)	0·2 of Ni	0·2 of Zn	Si
Si (= 5)	—	0·2 of Zn	Fe
Mn (= 6)	—	Zn	Fe
Cr (= 7)	—	Sn	Fe

Examples:

Specification	Basic Composition	Code No.
D.T.D. 197A	Al = 9·5%; Fe = 5%; Ni = 5%	1955
USA QQ-C-585 Comp. 6	Ni = 18% (× 0·2); Zn = 10% (× 0·2)	442–
USA QQ-C-586 Comp. 1	Ni = 18% (× 0·2); Zn = 17% (× 0·2)	443–
D.T.D. 355	Si = 3·5%; Zn = 2%; Fe = 1·7%	5422
USA QQ-C-591 Class A	Si = 2·52%; Zn < 4·25%; Fe < 1·6%; Sn < 1·5%; Mn < 1·5%	53—
D.T.D. 354	Cr = 1·25%; Sn = 2%; Fe = 1·75%	7122
D.T.D. 319	Si = 1·05%; Zn = 13·5%; Fe < 0·25%; Al = 0·95%; Ni = 1·1%	513–
USA QQ-C-586 Comp. 4	Ni = 18% (× 0·2); Zn = 19% (× 0·2); Pb = 1%	444–
USA QQ-B-721 Class B	Mn = 3·75%; Zn = 25% (× 0·2); Fe = 3%; Al = 4·5%	6453

The most difficult alloys have been picked as examples, and with the exception of D.T.D. 319 not much "stretching" was needed to apply the code. If a numbering scheme of four digits, such as the above, could be adequately improved to permit its general use, the colour coding would be very simple. Each figure could be represented by a colour ring put on the bar with a paint-soaked string (or webbing) or by sticking adhesive tape of the colour required. Such a colour code might also include letters, represented by different widths of rings, which could be used to define tempers or

indicate special features. The proposed coding would always be read from the nearest end of the bar and is as follows:

Colour	Meaning of the Width of Ring $\frac{1}{8}$ in.	$\frac{3}{8}$ in.	1 in.
White	1	A	M
Yellow	2	B	N
Green	3	C	P
Blue	4	D	Q
Violet	5	E	R
Red	6	F	S
Orange	7	G	T
Brown	8	J	W
Black	9	K	Y
Lilac	0	E	Z
Silver or Gold *	Dash	—	X

* Silver for copper alloys, gold for aluminium, magnesium, and nickel alloys of silverish colour.

It is realized that such a simple table of colour coding for the storekeeper, inspector, and shop foreman is proposed at the expense of the metallurgist, who would have to work hard on coding some of the more complex alloys, but if this effort were to contribute to the prevention of troubles in handling materials, it would be justified.

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High-Purity Titanium

The lowest hardness figure for pure titanium so far reported in the literature would seem to be 55 D.P.N.,[1, 2] and this was apparently obtained on metal prepared by the iodide decomposition method.* Metal normally produced by this process, however, is appreciably harder and usually lies within the hardness range 70–85 D.P.N.

In the course of the production of titanium by the Kroll process, we have observed that small quantities of metal having a well-developed crystalline form and brilliant surface lustre occasionally occur, some of the crystals being more than 1 cm. in length. Hardness measurements (which, on account of the time involved in carrying out the accurate determination of small quantities of oxygen and nitrogen in titanium, are customarily accepted as a convenient criterion of purity) indicate that the crystalline material is unusually free from impurities. We have melted some of the crystals after suitable surface-cleaning treatments, and have obtained hardness values within the range 50–55 D.P.N. The bulk of the melted material has a hardness between 60 and 65 D.P.N. These figures are the mean of four or five determinations on small arc-melted buttons, and should, therefore, be truly indicative of the hardness of the metal.

This crystalline material we describe may, therefore, be the purest titanium so far obtained, and an examination of it should facilitate a better understanding of the properties of the uncontaminated material than has hitherto been possible.

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NEWS OF KINDRED SOCIETIES

Société Française de Métallurgie

The Autumn Meeting of the Société Française de Métallurgie will be held at the Maison de la Chimie, Paris (7e), on 24–29 October. The two main subjects for discussion at the meeting will be: (1) the thermal treatment of light alloys, and (2) metallic alloys and cermets for high-temperature use.

At a recent meeting of the Council, M. Raoul de Vitry, Directeur-général of the Compagnie Péchiney, was elected President of the Société.

OTHER NEWS

" A Century of Aluminium "

A Friday evening discourse under this title was given at the Royal Institution, London, on 25 March, by Mr. George Boex, a Director (and former Joint Managing Director) of The British Aluminium Co., Ltd.

The immediate occasion for this centenary discourse was the fact that the first specimens of aluminium ever to be made in Britain were shown at the Royal Institution on 30 March 1855, very shortly after they were made by two students, R. Dick and A. Smith, working under Dr. John Percy at the old School of Mines. These actual specimens (lent by the Science Museum) were shown again during the discourse.

Although aluminium is the most abundant metal in the earth's crust, the difficult problem of isolating it from its compounds was not solved until a century ago. Deville in 1854 was the first to devise a chemical method which could be used to produce the metal as an article of commerce; but this method, like the variants of it which reached their highest development in Britain, was costly to carry out. At the peak of the " chemical " aluminium industry, about the year 1890, production was barely 50 tons a year, and the metal still sold at 16*s.* a pound. Its applications were therefore still confined to semi-luxury articles.

The modern industry stemmed from the discovery, made independently in 1886 by C. M. Hall in America and by P. L. T. Héroult in France, that the oxide of the metal when dissolved in molten cryolite (a rare mineral of which there is only one major deposit in the world—in Greenland) could be reduced to the metal by electrolysis. To isolate one ton of aluminium required 20,000 kWh. of electrical energy, and the application of the Hall–Héroult process thus needed cheap and abundant electrical power; but even by the end of the nineteenth century, production was already up to 7000 tons a year and the price of the metal down to 1*s.* a pound.

Increased familiarity with the metal led to widening demand for it in semi-fabricated forms, such as sheet and plate obtained by rolling and sections by extrusion: the development of these products meant a thorough investigation and progressive improvement of the industrial techniques. By dint

* It is not clear whether the hardness range quoted for this material (55–80 D.P.N.) indicated the scatter of values obtained from a series of impressions on the same material, or referred to a range of mean hardness values obtained on a series of samples.

of growing productive efficiency and rising scale of production, the selling price of aluminium had been kept relatively stable and its competitive position had correspondingly improved. Ample supplies of raw materials were available; but the geographical distribution of the basic industry had depended always upon the availability of abundant power supplies. There had been, in consequence, in recent years a notable increase in the proportionate contribution of Canada and the U.S.A. to world supplies of the metal.

All these points were analysed by Mr. Boex, who concluded that the remarkable growth of the world aluminium industry, now producing nearly 3 million tons of new metal a year and second, therefore, only to the iron and steel industries, was due first to growing efficiency of production, based on continuous research; and second, to the intelligent encouragement of suitable end-uses. As a result, the metal was now being used to a growing extent in all forms of transport, in building, in the electrical industry, in engineering industries generally, in packaging, and in the production of domestic hardware of many types.

Second Summer School in Corrosion

A Summer School will be held at Battersea Polytechnic from 19 to 22 July 1955, the subject being the " Oxidation of Metals ". The panel of lecturers will include Dr. W. Betteridge (Mond Nickel Co., Ltd.), Dr. T. P. Hoar (Cambridge University), Dr. I. Jenkins (G.E.C.), Dr. O. Kubaschewski (N.P.L.), Mr. R. L. Samuel (Diffusion Alloys, Ltd.), Mr. H. T. Shirley (Brown-Firth Research Laboratories), and Mr. J. Stephenson (U.K. Atomic Energy Authority).

The following aspects of the subject will be considered: theoretical principles of dry corrosion and anodic oxidation, oxidation and scaling of heat-resisting steels, alloys for electrical heating elements, nickel-base alloys for high-temperature use, oxidation-resistance of the rarer metals, diffusion coatings for resistance to oxidation, and the effect of gases on high-temperature oxidation.

In addition to the lectures, there will be discussions on the theoretical and practical aspects of oxidation, a demonstration and exhibition, a film show, and a works visit.

The fee for the course will be £3 3*s*. If required, accommodation during the course is available at the Polytechnic Hostel for an inclusive charge of £5 5*s*.

International Congress of Industrial Chemistry

The twenty-eighth International Congress of Industrial Chemistry will take place in Madrid from 23 to 31 October 1955. The Congress will be divided into twenty-three sections, one of which will be concerned with non-ferrous metals.

In addition to technical sessions, visits will be paid to works in the industrial regions of Spain.

Details may be obtained from the Secretariat of the Congress, Serrano 150, Madrid.

International Conference on Fatigue of Metals, 1956

The Council of the Institution of Mechanical Engineers are arranging an International Conference on Fatigue of Metals to be held from Monday, 10 September to Friday, 14 September 1956, inclusive. Sessions for the delivery of papers will be held daily from 10.00 a.m. to 12.30 p.m. and from 2.30 p.m. to 5.30 p.m.

It is hoped to obtain up to sixty papers covering the whole field, and these will be divided into groups, the papers in the various groups being presented for discussion in abstract form by Reporters.

The presentation of the papers will be preceded by an address reviewing the field of knowledge of fatigue. The address will be presented by Dr. H. J. Gough, C.B., M.B.E., F.R.S., a Past-President and Honorary Member of the Institution.

APPOINTMENTS VACANT